N89-21317

GEOLOGICAL REMOTE SENSING SIGNATURES OF TERRESTRIAL IMPACT CRATERS

J. B. Garvin and C. Schnetzler, NASA/GSFC, Code 622, Greenbelt, MD 20771; R. A. F. Grieve, Geol. Survey of Canada, Geophysics Division, 1 Observatory Crescent, Ottawa, K1A 0Y3.

Geological remote sensing techniques can be used to investigate structural, depositional, and shock metamorphic effects associated with hypervelocity impact structures, some of which may be linked to global Earth system catastrophies (e.g. biologic crises, climate fluctuations). Although detailed laboratory and field investigations are necessary to establish conclusive evidence of an impact origin for suspected crater landforms, the synoptic perspective provided by various remote sensing systems can often serve as a "pathfinder" to key deposits which can then be targetted for intensive field study. In addition, remote sensing imagery can be used as a tool in the search for impact and other catastrophic explosion landforms on the basis of localized disruption and anomaly patterns. In order to reconstruct original dimensions (and hence estimate energies of formation) of large, complex impact features in isolated, inaccessible regions, remote sensing imagery can be used (in spite of frequently variable levels of erosion) to make preliminary estimates in the absence of field geophysical surveys (i.e. gravity). The experience gained from two decades of planetary remote sensing of impact craters on the terrestrial planets [1-3], as well as the techniques developed for recognizing stages of degradation and initial crater morphology, can now be applied to the problem of discovering and studying eroded impact landforms on Earth. This report summarizes preliminary results of remote sensing analyses of a set of terrestrial impact features in various stages of degradation, geologic settings (i.e. targets), and for a broad range of diameters and hence energies of formation. The intention is to develop a database of remote sensing signatures for catastrophic impact landforms which can then be used in EOS-era global surveys as the basis for locating the possibly hundreds of "missing" impact structures [1,4]. In addition, refinement of initial dimensions of extremely recent structures (i.e., last 4 Myr) such as Zhamanshin and Bosumtwi is an important objective in order to permit re-evaluation of global Earth system responses (e.g. atmospheric dust loading, climate fluctuations) associated with these types of events.

Remote sensing datasets under examination include those obtained from Earth orbit: Landsat TM (visible, near-IR imaging), SPOT multispectral, Seasat SAR (L-band imaging radar), Large Format Camera (stereo, panchromatic photography), as well as those acquired with airborne systems such as TIMS (thermal IR imaging), INTERA SAR (digital X-band imaging radar with oblique viewing geometry), GEOSCAN (Visible-IR multispectral scanner), and laser altimeter (topographic profiles) [5]. *Table I* summarizes some of the initial results of the ongoing study. A detailed comparison of the visible, near-IR and thermal IR spectral signatures for impactite deposits at Meteor Crater provides evidence of the value of remote sensing imagery for discriminating basic components of fresh impact-generated landforms, including preserved ejecta, allogenic breccias, and post-impact infill. The TIMS data [6], when processed using various band decorrelation techniques [7], demonstrates subtle differences between thermal emission characteristics of the most highly shocked target rocks at the crater. In addition to the detection and measurement of surface ejecta and breccias, remote sensing data has been shown to be useful in defining crater structural features such as the tectonic rim, radial fracture patterns, terraces, etc. Laser altimeter topographic profiles with horizontal and vertical resolution as high as 1 m permit detailed assessment of ejecta blanket roughness and general crater morphometry. The Sedan nuclear explosion crater is under examination as a "control"; it represents an impact-like feature with freshly shocked materials in a pristine state at the surface. Particular attention has been given to the Zhamanshin and Bosumtwi structures on the basis of their association in time with major Earth system events such as short-lived magnetic reversals and climatic perturbations. At Zhamanshin, the outer ring

diameter of the structure has been shown to be at least 13 km [5,8,9], in contrast with earlier estimates of 5-6 km from field observations [10].

While remote sensing studies may not "prove" the existence of hundreds of impact craters, they can uniquely identify candidate structures worthy of intensive field and laboratory study, especially if a systematic basis for discovering such features in synoptic imagery is established. This ongoing work is a first step in that direction.

REFERENCES: [1] Grieve R.A.F. (1987) Ann. Rev. Earth Planet. Sci. 15, 247-270. [2] Grieve R.A.F. and J. W. Head (1981) Episodes 1981, no. 2, 3-9. [3] Grieve R.A.F. et al. eds. (1988) *Astronauts Guide to Terrestrial Impact Craters*, LPI Tech. Report 88-03, LPI, Houston, TX, 89pp. [4] Shoemaker E. M. and R. Wolfe (1987) *Mass extinctions, crater ages, and comet showers*, in The Galaxy and Solar System, U. Arizona Press, 83 pp. [5] Garvin J. B. et al. (1988) LPSC XIX, p. 375-376, LPI, Houston. [6] Palluconi F. and G. Meeks (1985) *Thermal IR Multispectral Scanner*, JPL Public. 85-32. [7] Gillespie A. et al. (1986) Rem. Sens. Env. 20, 209-235. [8] Masaitis V. L.(1987) *Elements of Bilateral Symmetry at Impact Crater Zhamanshin*, Meteoritika 46, 119-123 (in Russian). [9] McHone J. and R. Greeley (1981) NASA TM-84211, 78-80, Washington, DC. [10] Florensky P. V. and A. Dabizha (1980) *Zhamanshin Meteorite Crater*, Nauka Press, Moscow, 127 pp. (in Russian).

IMPACT CRATERS UNDER STUDY

CRATER NAME	DIAM. (km)	AGE (Myr.)	LOCATION	DATASETS*	RESULTS
SEDAN	0.37	1961#	NV	TM	DEFINE EJECTA BLANKET
METEOR	1.2	0.049	AZ	TM, TIMS, ASAR, SEASAT, ALA	EJECTA, ALLOGENIC BRECCIAS DETECTED
ZHAMANSHIN	13	0.750	USSR	TM	DETECTED ALLOGENIC BRECCIAS, OUTER RIM
BOSUMTWI	10.5	1.1	GHANA	SPOT XS	LOCATED OUTER TECTONIC RIM
ELGYGYTGYN	23	3.5	USSR	SPOT XS, SEASAT	RADIAL FRACTURE PATTERN MEASURED
BIGATCH	7	6	USSR	SPOT XS	DEFINED INTERIOR STRUCTURE, RIM
RIES	25	14.8	FRG	TM	SPECTRAL SIGNATURE OF SUEVITE QUARRIES
GOAT PADDOCK	7	55	W.A.	TM, LFC	SIGNATURE OF ALLOGENIC MELT BRECCIAS
TIN BIDER	7	70	ALGERIA	TM, LFC	CRATER FLOOR AND BASEMENT STRUCTURE
GOSSES BLUFF	22	142	N.T.	GEOSCAN, LFC ASAR	SHOCKED SANDSTONES FROM SUB-FLOOR
ROTER KAMM	2.5	< 5	NAMIBIA	TM	RIM MORPHOMETRY AND EXHUMATION
AL MADAFI	5.5+	< 360	SAUDI ARABIA	TM	INNER RING, SPECTRAL ANOMALY PATTERN
ITTURALDE	8	< 0.015	BOLIVIA	TM, SPOT?	RIM STRUCTURE, DETECTED TERRACES

*NOTES: DATASET TYPES KEY:

TM:	LANDSAT THEMATIC MAPPER (VIS, IR)
SPOT XS:	SPOT MULTISPECTRAL HRV (VIS, IR)
TIMS:	THERMAL IR MAPPING SPECTROMETER (AIRBORNE)
LFC:	LARGE FROMAT CAMERA (SHUTLE) PANCHORMATIC
ASAR:	AIRBORNE SAR (INTERA) (X-BAND)
SEASAT:	SEASAT ORBITAL SAR (L-BAND)
ALA:	AIRBORNE LASER ALTIMETRY
GEOSCAN:	GEOSCAN LTD. AIRBORNE MULTISPECTRAL SCANNER (VIS, IR, THERMAL IR)

1961 is year (AD) of 150 Kiloton nuclear explosion